# PATENT SPECIFICATION

(11) 1 205 800

DRAWINGS ATTACHED

(21) Application No. 57177/67 (22) Filed 15 Dec. 1967
(31) Convention Application No. 83419 (32) Filed 16 Dec. 1966 in
(33) Japan (JA)
(45) Complete Specification published 16 Sept. 1970
(51) International Classification D 03 d 1/00
(52) Index at acceptance
D1K 215 245 384 423 424 425 426 427 433 434 457 474 480 541 571 57Y 580 581 584 585 588 654 65Y 661 662 687 68Y 793
H5H 2B4F

## (54) IMPROVEMENTS IN OR RELATING TO WOVEN ELECTRIC RESISTANCE ELEMENTS

(71) We, MATSUSHITA ELECTRIC INDUSTRIAL COMPANY LIMITED, a Japanese Company, of Kadoma, Osaka, Japan, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to woven resistance elements.

Conventional woven resistance elements of the type in which an electrical resistance wire is woven into a fabric base have the drawback that the appearance of the element is spoiled by wrinkles or frizzles present in the surfaces thereof. These wrinkles are caused by the fact that, in weaving the heating wire with warp yarns together with a weft yarn, the resistance wire is slackened as the movement of a shuttle carrying the wire is reversed, thus allowing the latter to depart from its predetermined rectilinear state due to the curvature imparted previously to the wire during storage on a spool.

It is, therefore, an object of the present invention to reduce the aforestated drawback.

According to the present invention there is provided a woven heater comprising a fabric base woven with warp threads consisting of an electrically insulating fibrous material and weft threads consisting of such electrically insulating fibrous material, conductor wires woven into said fabric base in the areas adjacent respective selvages of the fabric base and extending in the direction of the warp, and heating wires each having an electrically insulating yarn wound thereon, said heating wires being woven in the direction of the weft into said fabric base, whereby an outer selvage section, a conductor wire section comprising said conductor wires, an intermediate selvage section, an inner selvage section and a central section are formed in the order mentioned from opposite side edges of the woven fabric towards the centre thereof in the direction of weft, the warp density being from 50 to 100 yarns per centimeter in the outer selvage section, from 30 to 64 wires per centimeter in the conductor wire section, from 50 to 100 yarns per centimeter in the intermediate selvage section, from 50 to 100 yarns per centimeter in the inner selvage section and from 10 to 30 yarns per centimeter in the central section, and the total weft density being from 10 to 30 yarns per centimeter.

Also according to the present invention there is provided a woven heater comprising a fabric base woven with warp threads consisting of an electrically insulating fibrous material and a weft consisting of such electrically insulating fibrous material, conductor wires woven into said fabric base in the areas adjacent respective selvedges of the fabric base and extending in the direction of the warp, and heating wires each having an electrically insulating yarn wound thereon, said heating wires being woven in the direction of the weft into said fabric base in a manner that said heating wires provide a plurality of separate unit heating regions of a predetermined length in the warp direction of said woven fabric base, said heating regions being spaced from each other by a zone of fabric which is composed solely of said warp and weft yarns, said conductor wires being floated above the surface of the fabric at optional locations, there being an outer selvage section, a conductor wire section comprising said conductor wires, an intermediate selvage section, an inner selvage section and a central section in the order mentioned from opposite side edges of the woven fabric towards the centre thereof in the direction of weft, the warp density being from 50 to 100 yarns per centimeter in the outer selvage section, from 30 to 64 wires per centimeter in the conductor wire section, from 50 to 100 yarns per centimeter in the intermediate selvage section, from 50 to

[F. ]

100 yarns per centimeter in the inner selvage section and from 10 to 30 yarns per centimeter in the central section, and the total weft density being from 10 to 30 yarns per centimeter.

The present invention will be now further described in part with reference to the accompanying drawing which shows an embodiment thereof, and in which:

Figure 1 is a diagrammatic plan view of a woven resistance element according to an embodiment of the present invention; and

Figure 2 is a fragmentary plan view in enlargement of the woven resistance element shown in Figure 1.

Referring to the drawings, there is shown a woven fabric 5 which is woven with warp threads 1 consisting of a 240 denier filament of Vinylon (trade name) and weft threads 3 consisting of a 500 denier yarn of Vinylon, into which are woven conductor warp wires 2,2′ consisting of soft copper wire of 0.18 mm in diameter and heating resistance weft wires 4 consisting of stainless steel wire of SUS 27 grade, that is 18—8 Cr—Ni steel (austenite), and of 0.1 mm in diameter, the heating wires 4 having a Vinylon yarn 4¹ wound thereon at a density of 470 turns perimeter. The woven resistance fabric 5 is composed of outer selvage sections 6, 2 mm wide arranged along opposite side portions of the fabric and each comprising twelve warp yarns 1. Conductor wire sections 7, 2.5 mm wide and each comprising sixteen conductor wires 2 or 2¹. are arranged adjacent to the respective outer selvage sections. Two intermediate selvage sections 8, 5 mm wide and each comprising twenty-five warp yarns 1, are arranged adjacent to the respective conductor wire sections. Inner selvage sections 9, 3 mm wide and each comprising twenty-two warp yarns 1, are arranged adjacent to the respective intermediate selvage sections, and a central section 10 comprising warp yarns 1 at a density of twenty yarns per centimeter is arranged between the inner selvage sections 9. It should be mentioned that for the sake of clarity the Figures do not in some cases illustrate the number of warp yarns stated above.

Resistance wire 4 is woven in the fabric at a density of 11 wires per centimeter and a weft yarn 3 is disposed between adjacent resistance wires 4 and also outside the top and bottom heating wires 4 as viewed in Figure 1 so that the overall density of the resistance wires and weft yarns is 23 wires and yarns per centimeter.

The resistance wires 4 are woven in the fabric in such a manner as to form a plurality of separate unit resistance regions which are spaced from each other by zones 12 of fabric which are composed solely of the warp and non-conductive weft yarns 3. The conductor wires 2, 2¹ are partially raised to the surfaces of the woven fabric at optional locations by floating. Portions of the resistance wire are extended outwardly as indicated at 11, 11¹ for connection to the respective conductor wires 2, 2¹ and silver paint is applied to the contacting portions.

The materials used in carrying out the invention preferably consist of a yarn of synthetic fibre or glass fibre of 100 to 300 denier as the warp yarn 1, a yarn of synthetic fibre or glass fibre of 300 to 4000 denier as weft yarn 3, a stainless steel wire, for example, of SUS 27 grade having a diameter of 0.05 to 0.15 mm as the resistance weft wire and a soft copper wire of 0.1 to 0.2 mm in diameter for example, as conductor warp wires 2.

The yarn used for the warp yarns 1 is made of a synthetic fibre or glass fibre, such as the fibre known as Tetoron (trade name) or Vinylon (trade name), and has a size of 100 to 300 denier, preferably 240 denier. Although yarn of a size smaller than 100 denier can be woven the smaller the diameter of the yarn used, the higher will be the cost of the resultant product, because the yarns should be beaten-up more densely in order to maintain the shape of the product. On the other hand, the use of a yarn of a size greater than 300 denier will result in shrinkage of the resistance element produced. For this reason, it is preferable to use a yarn of a size ranging from 100 to 300 denier.

The yarn used for the warp is given a twist of from 300 to 500 turns, preferably 450 turns, per meter. The twisted yarn is preferably subjected to steam setting for 10 minutes in an atmosphere of steam at 100°C and is then sized with a polyvinyl alcohol paste and is then dried. These treatments are applied in order to prevent the yarn from fluffing, to avoid shrinkage of the resultant fabric and to harden the yarn to prevent the woven fabric as a whole from losing its shape. Upon completion of the preliminary treatment described above, the warp is beamed at a predetermined density.

A description will now be given of the preferred warp densities in various sections of the fabric. The warp densities in the fabric must be selected properly taking into account the fact that an excessively high density will render the resultant fabric unsatisfactory in respect of flexibility, while an excessively low density will render the fabric unacceptable in respect of strength. For these reasons the warp density in the outer selvage section should be from 50 to 100 yarns per centimeter, preferably 8 yarns per 1.5 mm. The width of the outer selvage section is only required to be greater than 1 mm and will normally be from 1.5 to 4 mm and preferably 1.5 mm. An excessively small width of the outer selvage section is disadvantageous in that the conductor wires in the warp are pulled inwardly by the weft and cannot be held in a rectilinear state. On the other hand, an excessively great width of the outer selvage section, though not detrimental, is useless unless this section is used for securing the fabric or for other purposes. For this

reason, the width of the outer selvage sections is preferably limited to not more than about 4 mm.

Disposed inwardly of the outer selvage section is the conductor wire section in which soft copper warp wires serving as conductor wires, the number of which is determined by the current to be handled, are woven with the weft. The conductor wires are woven in at a density of from 30 to 64 wires per centimeter, and in one preferred arrangement the density is 37 wires per centimeter. The width of the conductor wire section is from 2 to 4 mm, preferably 2.5 mm.

Inside the conductor wire section is provided the intermediate selvage section. This section is provided to ensure insulation between the conductor wires and the resistance wires and its width is preferably at least 5 mm and may be 20 or even 30 mm in some instances. The warp density in this section is from 50 to 100 yarns per centimeter, which is the same as that in the outer selvage section, and is preferably 25 yarns per 5 mm. Normally, it is preferable for the intermediate selvage section 8 to have a warp density which is 2 to 6 times as high as that in the central section 10. An excessively low warp density in the former section would result in distortion of the resultant fabric and would also result in unsatisfactory insulation between the conductor wires and the resistance wires as a result of the former being pulled towards the latter, so that the distance between them was reduced. On the other hand, as exceedingly high warp density in this section would result in a hardening of the section, causing a waviness in the resultant fabric so that the appearance of the resistance element produced would be spoiled.

Disposed inwards of and adjacent to the intermediate selvage section is the inner selvage section. This section is provided for the purpose of imparting to that portion of the fabric where the resistance wires loop during the weaving operation, a strength capable of withstanding the tension of the resistance wire. The width of this section is from 3 to 10 mm, preferably 3 mm, while its warp density is from 50 to 100 yarns per centimeter and is preferably 60 yarns per centimeter which is sufficient to fulfill the purpose described. An excessively low warp density in this section will result in distortion of the fabric being woven.

Between the opposed inner selvage sections is provided the central section. The warp density in this section may be as low as from 10 to 30 yarns per centimeter and is preferably 20 yarns per centimeter. The density selected for the warp yarns in this section need only be sufficient to prevent loosening of the structure of the woven fabric.

As described previously, the weft yarn 3, like the warp yarn 1, is made of a synthetic fibre or glass fibre. The yarn consists of staple fibres which are formed by doubling and twisting short fibres. Before the yarn is used in weaving the fabric, it is preferably sized with polyvinyl alcohol and dried at 65°C. for 10 hours. The sizing is performed for the purpose of avoiding shrinkage of the resultant fabric and also to harden the yarn so as to prevent distortion of the resultant woven fabric as a whole. The size of the weft is determined by the pitch at which the heating wire is woven and is normally in the range from 500 to 1000 denier. Where it is desired to produce a resistance element of small thickness it is obviously necessary to use a weft of a small diameter. When, on the other hand, a thick weft is woven coarsely, the resultant woven resistance element accordingly becomes thicker, although its cost is reduced.

When the size of the yarn to be used for the weft has once been determined from the considerations mentioned above, a suitable weft density can be determined by the pitch at which the resistance wire is to be woven in the fabric. For instance considerations of satisfactory insulation between adjacent portions of the resistance wire determine that the maximum density at which the resistance wires should be woven is 12 wires per centimeter. In this case, the weft yarn is to be arranged alternatively with the heating wire and the over all density of the resistance wires and weft yarns will be 25 wires and yarns per centimeter.

Referring next to the resistance wire, stainless steel of grades up to SUS 27 and of a diameter up to 0.05 to 0.15 mm is weavable. However, when such thin wire is used bare, the difficulty is encountered that during the weaving operation the resistance wire may be broken due to the frictional heat developed. This difficulty may be avoided by winding a yarn on the resistance wire before weaving. For this purpose, a yarn similar to that employed as the weft yarn is used. The size of the yarn is essentially determined by the thickness of the resistance wire used. For example, a yarn of 300 to 600 denier may be used for a resistance wire of 0.1 mm diameter and a yarn of 600 to 1200 denier for a resistance wire of 0.15 mm diameter.

Before winding on to the resistance wire, the yarn is given a twist of 400 to 500 turns per meter in the anticlockwise direction. This additional twist is necessary because normally the yarn in its initial state is already twisted in the anticlockwise direction at about 400 turns per meter, so that, if the yarn were wound directly on the resistance wire, it would be twisted in the clockwise direction which wuld mean that the twist originally possessed by the yarn was reversed. If the yarn is thus untwisted, excessive fluffing is caused during the weaving operation and, in some instances, the yarn may even be decomposed to such an extent that it is no longer weavable. It is for

this reason that the yarn is twisted by 400 to 500 turns per meter in the anticlockwise direction before it is wound on to the resistance wire. In this state, as will be appreciated, the yarn has been twisted at 800 to 900 turns per meter in the anticlockwise direction, including the twist originally imparted to the yarn.

After the yarn in this twisted state is wound on the resistance wire at about 470 turns per meter, the twist remaining in the yarn is just about the same as that which it originally possessed. In this case, it should be noted that excessive twisting of the yarn before winding on to the resistance wire will result in slipping of the yarn on the surface of the heating wire during the weaving operation, with the result that the turns of the yarn become bunched. For this reason, the yarn is required to be twisted at only 400 to 500 turns per meter and preferably at 470 turns per meter. Insufficient twisting of the yarn will produce less friction reducing effect, whereas excessive twisting will cause unsatisfactory contact between the resistance and conductor wires and therefore is not desirable,

In that region 11 of the conductor wire section into which the resistance weft wires project the weft yarns and the resistance weft wires are disposed alternately and each of the conductor wires extends alternately over and beneath the successive weft yarns and resistance wires thus disposed. In other portions of the conductor wire section wherein no resistance wires are interlaced, on the other hand, the conductor wires may extend in such manner that each of them runs over two or three weft yarns and then beneath the following two or three weft yarns and this continues until the next projecting portion of resistance wire is reached.

This mode of weaving eliminates the liability of the conductor wires being cut or snapped and a conductor wire section of this construction is stiff.

The resistance fabric woven as described above is preferably coated at portions where the conductor wires contact the heating wire with an electrically-conductive paint, e.g. silver paint, in order to ensure satisfactory electrical contact between the wires.

As described previously, the weft density is determined by the diameter of the resistance wire to be woven in and the size of the yarn to be used as the weft. The maximum density of the resistance wires is 12 wires per centimeter, because a density higher than this will result in undesirably reduced flexibility of the resultant resistance fabric. Between adjacent resistance wires is disposed at least one weft yarn. From the standpoint of flexibility of the resultant heating fabric, the overall density of the resistance wires and weft yarns is preferably not higher than 25 wires and yarns per centimeter. In weaving the heating fabric, it is preferable that the resistance wire, having a yarn wound thereon, is woven into the fabric so that it forms a plurality of separate unit resistance regions of a common predetermined length, adjacent resistance regions being spaced from each other by a zone of fabric which is composed solely of the insulating warp and nonconductive weft yarns; that the conductor wires are floated over the surfaces of the woven fabric at predetermined locations and that the turns of the resistance wire at each side of the fabric are partially interlaced with or wound about the conductor wires on the respective side.

In use of a resistance fabric woven in the manner described as a planar heating element, the surfaces of the resistance fabric are insulated by embedding the fabric in a synthetic resin by impregnating it with the synthetic resin, or by covering its surfaces with cushioning fabrics, such as glass mats or glass cloths, which are heat bonded under pressure to the surfaces from both sides by means of a thermosetting resin with which they are impregnated, or by covering the surfaces with sheets of synthetic resin which are attached thereto by means of an adhesive, or by covering the surfaces with thermoplastic resin sheets melt-bonded thereto with heat.

An example wherein the resistance fabric is used as a planar heating element is described below.

A resistance fabric obtained in the manner described above was coated with styrene monomer and was embedded in a maleic acid phthalate polyester resin in the manner described below. Specifically, two sheets of tempered glass were provided and a releasing agent, such as, for example, polyvinyl alcohol, was applied thinly to the surface of one of said sheets of glass. Over the layer of releasing agent was coated a maleic acid phthalate polyester resin and the surface of said resin coating was then sprayed with styrene monometer to eliminate air bubbles present in the resin. When the resin was partly solidified into a jelly-like state, the resistance fabric previously coated with styrene was placed on the jelly-like resin and then the top surface of the styrene-coated fabric was uniformly coated with a small amount of maleic acid phthalate polyester resin and further with styrene to free the resin of air bubbles. The other sheet of tempered glass, having a layer of jelly-like maleic acid phthalate polyester resin previously formed on a surface thereof in the manner described above, was then placed on the fabric with the jelly-like layer facing downwardly so carefully that no air bubbles were trapped between the fabric and the glass. A pressure of 1 kg/cm² was applied continuously to the top glass until the resin interior of the sheets of glass presented a jelly-like state. Then followed heating at 60°C to 80°C. for 10 to 20 minutes, thereby to cure the resin. After curing, the resin was allowed to cool to about

40°C. and then the sheets of tempered glass were removed, whereupon the desired planar heating element was obtained.

A planar resistance element produced in the manner described hereinabove is advantageous in that it is free from wrinkle, because, since the resistance wire is woven partially in place of the weft yarn, it is not permitted, during the weaving operation, to become slack nor to curve as a result of the curvature previously imparted to the resistance wire during storage on a spool.

Another advantage of the inventive planar heating element is that, since the adjacent unit heating regions of a predetermined heating capacity or a predetermined resistance may be spaced from each other by a zone of fabric which is composed solely of the insulating warp and nonconductive weft yarns, not only is it possible to obtain positive insulation between the resistance wires in adjacent resistance regions but also the regions can easily be separated from one another by cutting the intervening fabric. In addition, when holes are required to be bored at a portion of a plastic embedded resistance element for support or for other purposes, such holes can be provided in the insulating zone of fabric formed between adjacent resistance regions. Still another advantage of the invention is that the resistance wires in respective unit heating regions may be connected in series or in parallel by cutting the portions of the lead wires which float on the surfaces of the woven fabric at optional locations and this advantageous effect of the invention may be further enhanced by using an arrangement in which a plurality of unit resistance regions are provided as previously described for separation from one another. A resistance element constructed in accordance with the invention has a high flexibility and a sufficient strength. Furthermore, since the surfaces of the inventive heating element may be covered with a material such as synthetic resin, the heating element itself is not subjected to atmospheric influences and has an acceptable feeling to the human skin when used as a body-heating appliance.

WHAT WE CLAIM IS:—

1. A woven heater comprising a fabric base woven with warp threads consisting of an electrically insulating fibrous material and weft threads consisting of such electrically insulating fibrous material, conductor wires woven into said fabric base in the areas adjacent respective selvages of the fabric base and extending in the direction of the warp, and heating wires each having an electrically insulating yarn wound thereon, said heating wires being woven in the direction of the weft into said fabric base, whereby an outer selvage section, a conductor wire section comprising said conductor wires, an intermediate selvage section, an inner selvage section and a central section are formed in the order mentioned from opposite side edges of the woven fabric towards the centre thereof in the direction of weft, the warp density being from 50 to 100 yarns per centimeter in the outer selvage section, from 30 to 64 wires per centimeter in the conductor wire section, from 50 to 100 yarns per centimeter in the intermediate selvage section, from 50 to 100 yarns per centimeter in the inner selvage section and from 10 to 30 yarns per centimeter in the central section, and the total weft density being from 10 to 30 yarns per centimeter.

2. A woven heater according to claim 1 said heating wires being interlaced into said fabric base in such a manner that said heating wires provide a plurality of separate unit heating regions of a predetermined length longitudinally of said woven fabric base, said heating regions being spaced from each other by respective zones of fabric composed solely of insulating warp and nonconductive weft yarns, said conductor wires being floated above the surface of the fabric at optional locations.

3. A woven heater according to Claim 1, wherein the intermediate selvage section has a warp density of from 2 to 6 times the warp density of the central section.

4. A woven heater according to Claim 1, wherein the warp density of the outer selvage section is 8 yarns per 1.5 millimeters, of the conductor wire section is 37 wires per centimeter, of the intermediate selvage section is 5 yarns per millimeter, of the inner selvage section is 60 yarns per centimeter and of the central section is 20 yarns per centimeter.

5. A woven heater according to Claim 1, wherein the width of the outer selvage section is from 1 millimeter to 4 millimeters, of the conductor wire section is from 2 millimeters to 4 millimeters, of the intermediate selvage section is from 5 millimeters to 30 millimeters, and of the inner selvage section from 3 millimeters to 10 millimeters.

6. A woven heater according to Claim 5, wherein the width of the outer selvage section is 1.5 millimeters, of the conductor wire section is 2.5 millimeters, of the intermediate selvage section is 5 millimeters, and of the inner selvage section is 3 millimeters.

7. An electric resistance element substantially as hereinbefore described with reference to the accompanying drawing.

A. A. THORNTON & CO.,
Chartered Patent Agents,
Northumberland House,
303—306 High Holborn,
London, W.C.1.

Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1970.
Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.

1205800 COMPLETE SPECIFICATION

1 SHEET *This drawing is a reproduction of the Original on a reduced scale*

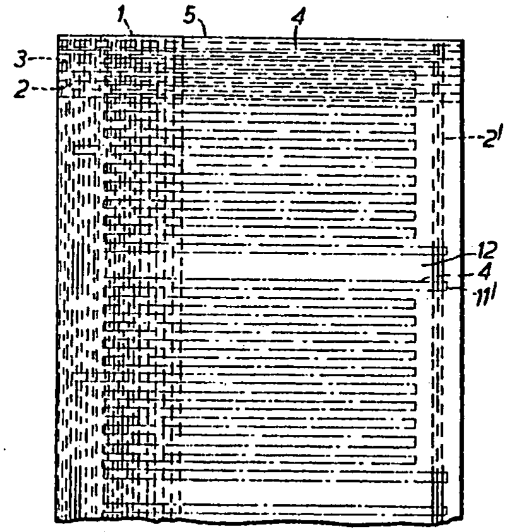


FIG. 1.

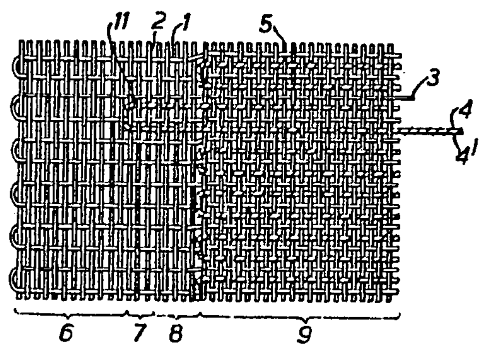


FIG. 2.

D: <GB___1205800A__I_>